US008220804B2

(12) **United States Patent**
Erickson

(10) **Patent No.: US 8,220,804 B2**
(45) **Date of Patent: Jul. 17, 2012**

(54) **TOOLHOLDER ASSEMBLY WITH AXIAL CLAMPING MECHANISM**

(75) Inventor: **Robert A. Erickson**, Raleigh, NC (US); **Carla Erickson**, legal representative, Raleigh, NC (US)

(73) Assignee: **Kennametal Inc.**, Latrobe, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 834 days.

(21) Appl. No.: **12/366,137**

(22) Filed: **Feb. 5, 2009**

(65) **Prior Publication Data**

US 2010/0196113 A1 Aug. 5, 2010

(51) **Int. Cl.**
B23B 31/107 (2006.01)

(52) **U.S. Cl.** **279/2.11**; 279/2.23; 82/160

(58) **Field of Classification Search** 279/2.11, 279/2.12, 2.1, 2.23; 82/158, 160; 409/233
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,866,529	A	7/1932	Farkas
3,254,567	A	6/1966	Daugherty
3,730,637	A	5/1973	Cellini
4,499,800	A	2/1985	Stahl
4,691,929	A	9/1987	Neumaier et al.
4,736,659	A	4/1988	Erickson
4,747,735	A	5/1988	Erickson et al.
4,836,068	A	6/1989	Erickson
4,981,057	A	1/1991	von Haas et al.
5,040,932	A	8/1991	Oshnock
5,054,344	A	10/1991	Erickson et al.
5,173,017	A	12/1992	Oshnock et al.
5,245,896	A	9/1993	Erickson et al.
5,279,194	A	1/1994	Armbrust
5,415,066	A	5/1995	Erickson et al.
5,452,631	A	9/1995	Erickson
5,694,820	A	12/1997	Erickson et al.
5,697,740	A *	12/1997	Von Haas et al. 409/234
5,997,455	A *	12/1999	Matsuoka et al. 483/56
6,000,940	A	12/1999	Buss et al.
6,270,293	B2	8/2001	Erickson et al.
6,966,728	B1	11/2005	Erickson
7,357,608	B2	4/2008	Erickson et al.
7,360,974	B2	4/2008	Borschert et al.
7,418,783	B2 *	9/2008	Fujimoto et al. 29/896.9

FOREIGN PATENT DOCUMENTS

GB	278625		10/1927
JP	58051042	A *	3/1983
JP	11090708	A *	4/1999

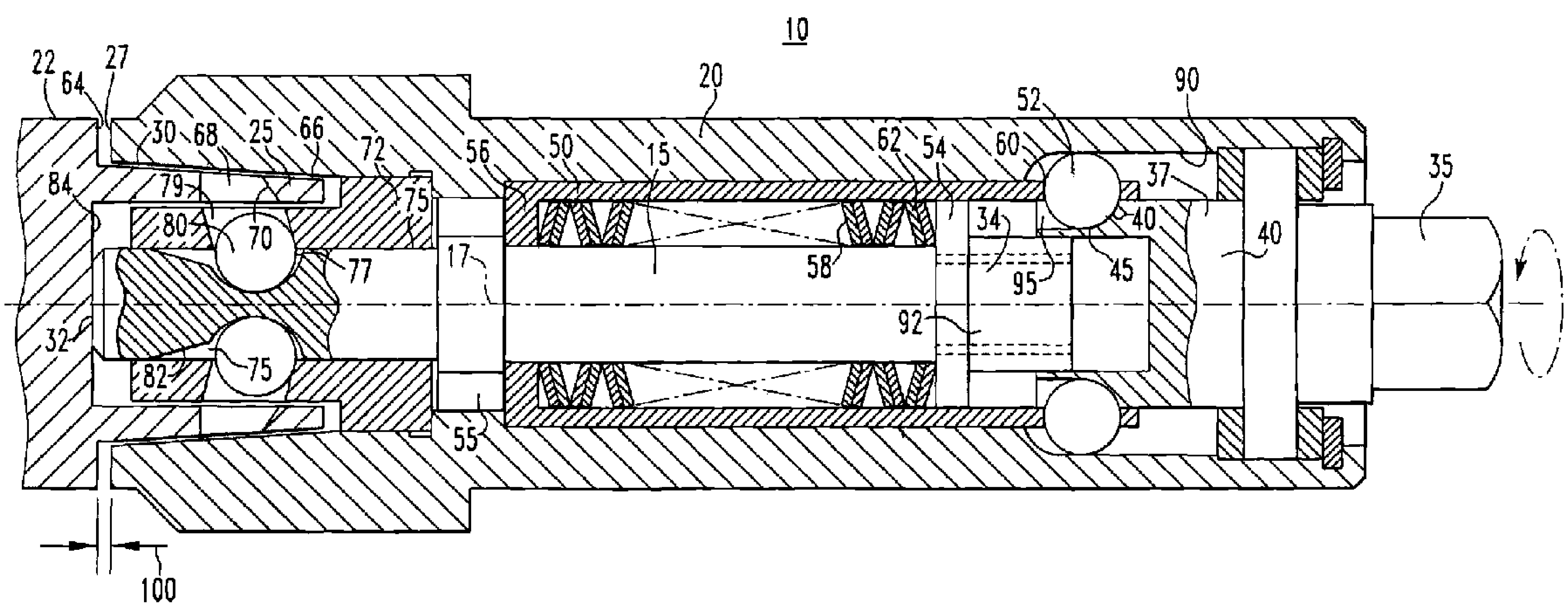
* cited by examiner

Primary Examiner — Daniel Howell
Assistant Examiner — Paul M Janeski
(74) *Attorney, Agent, or Firm* — Larry R. Meenan, Esq.

(57) **ABSTRACT**

An apparatus for releasably holding a tubular toolholder shank by axially reciprocating a lock rod between a locked and unlocked position. Compression balls following a helical path on a torque nut are used to retract a compression sleeve, which in turn compresses springs against the lock rod to move the lock rod into the locked position. As a result, a repeatable lock rod force is possible with a pre-determined and self limiting rotation of the torque nut. The same helical groove may be used to advance the compression sleeve against the lock rod to urge the toolholder from the base member.

24 Claims, 7 Drawing Sheets



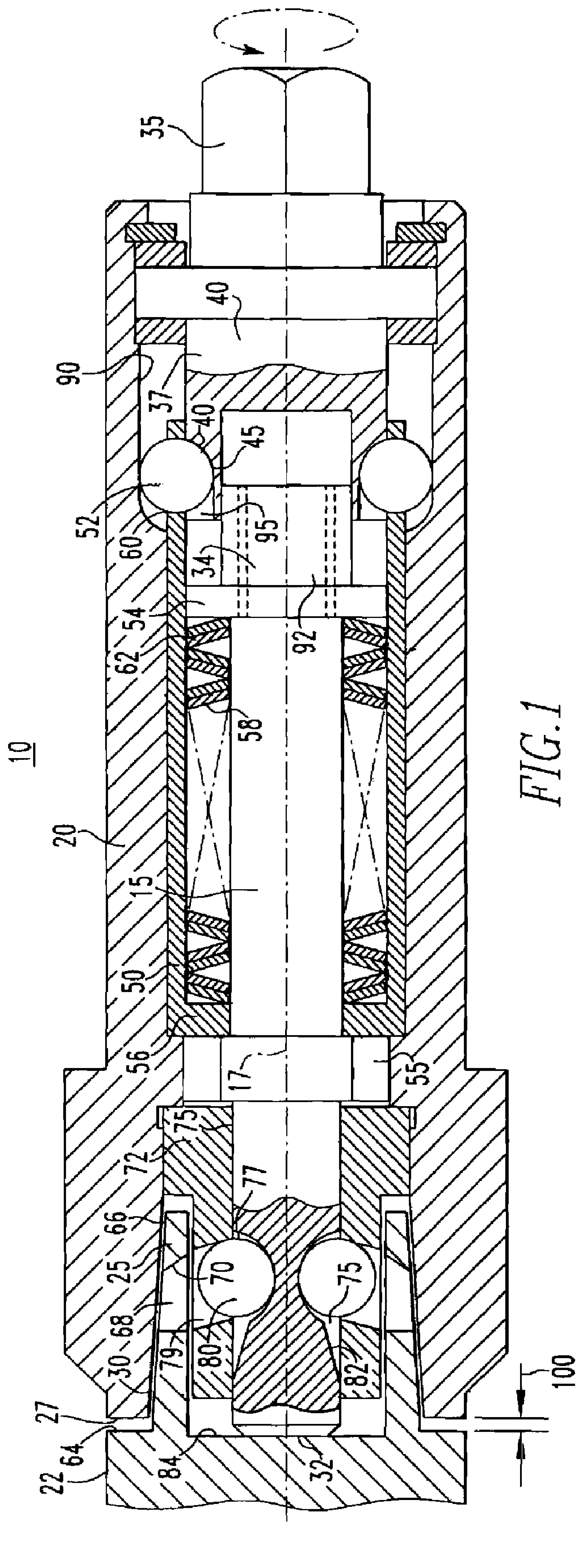

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FIG. 1

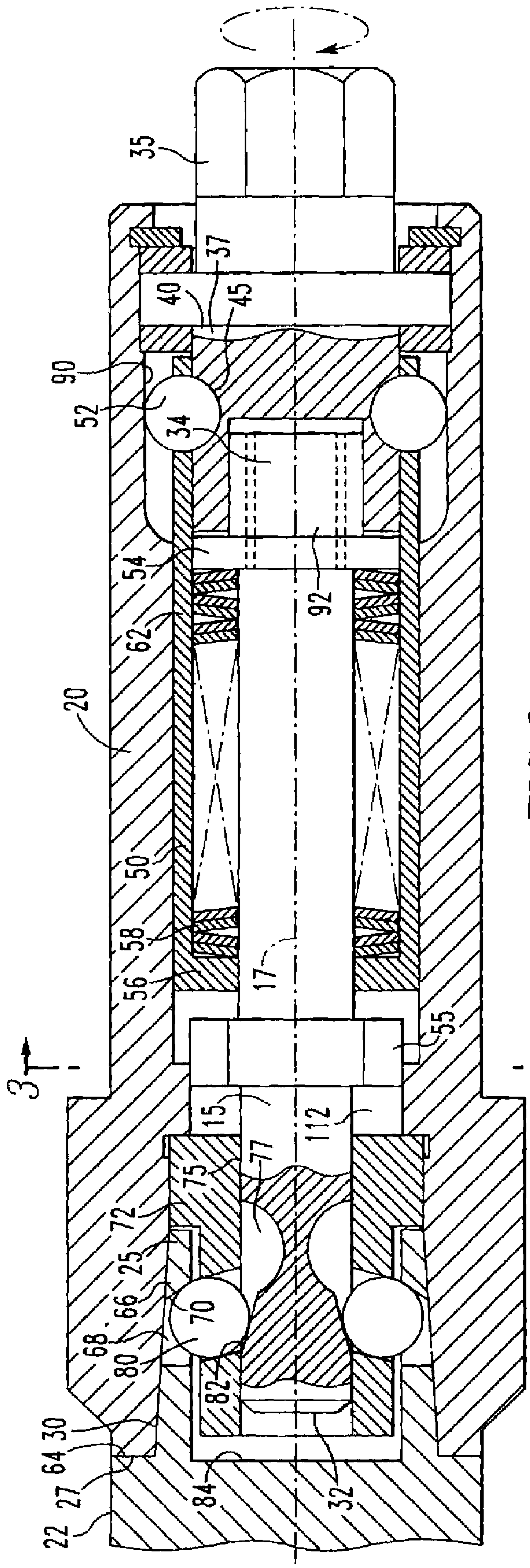
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FIG. 2

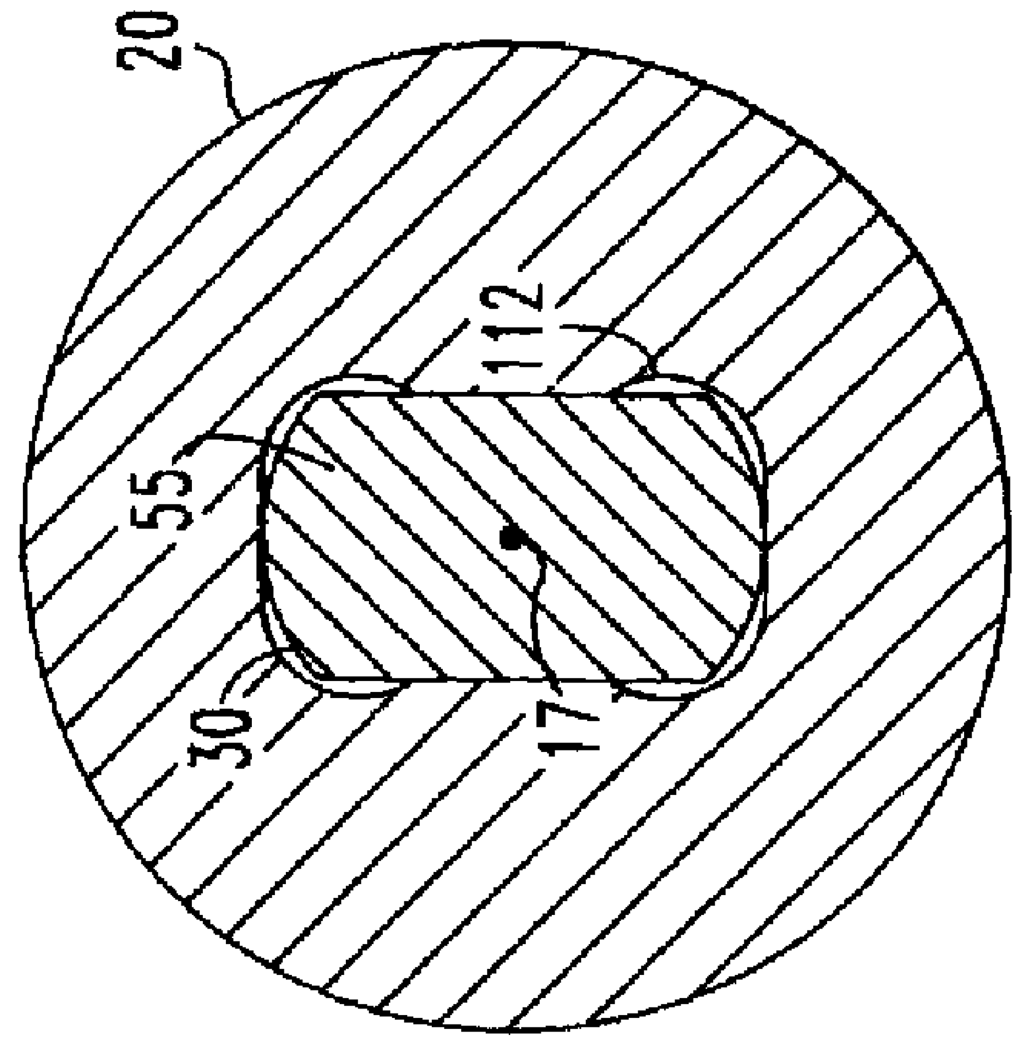
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FIG. 3

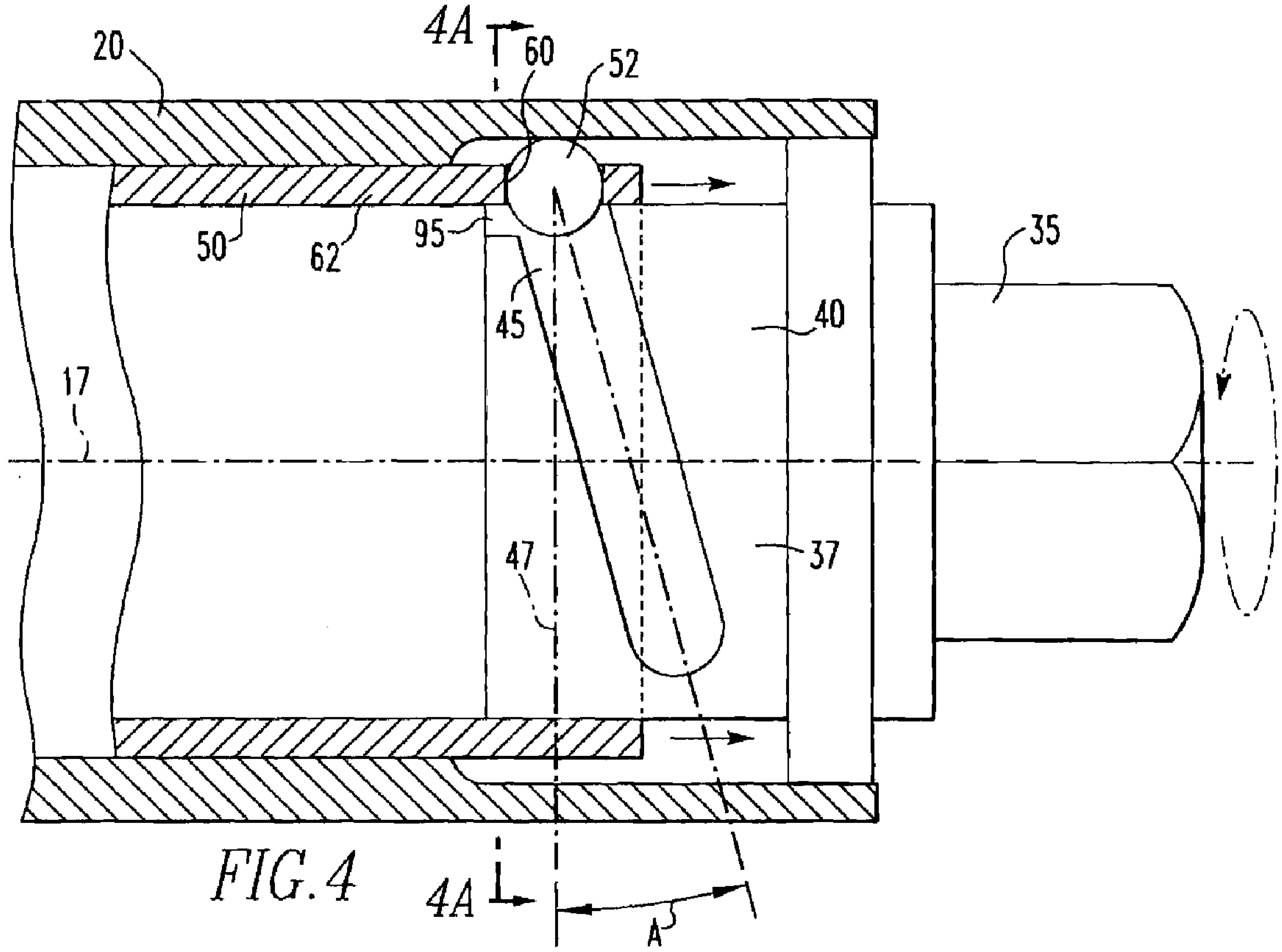


FIG.4

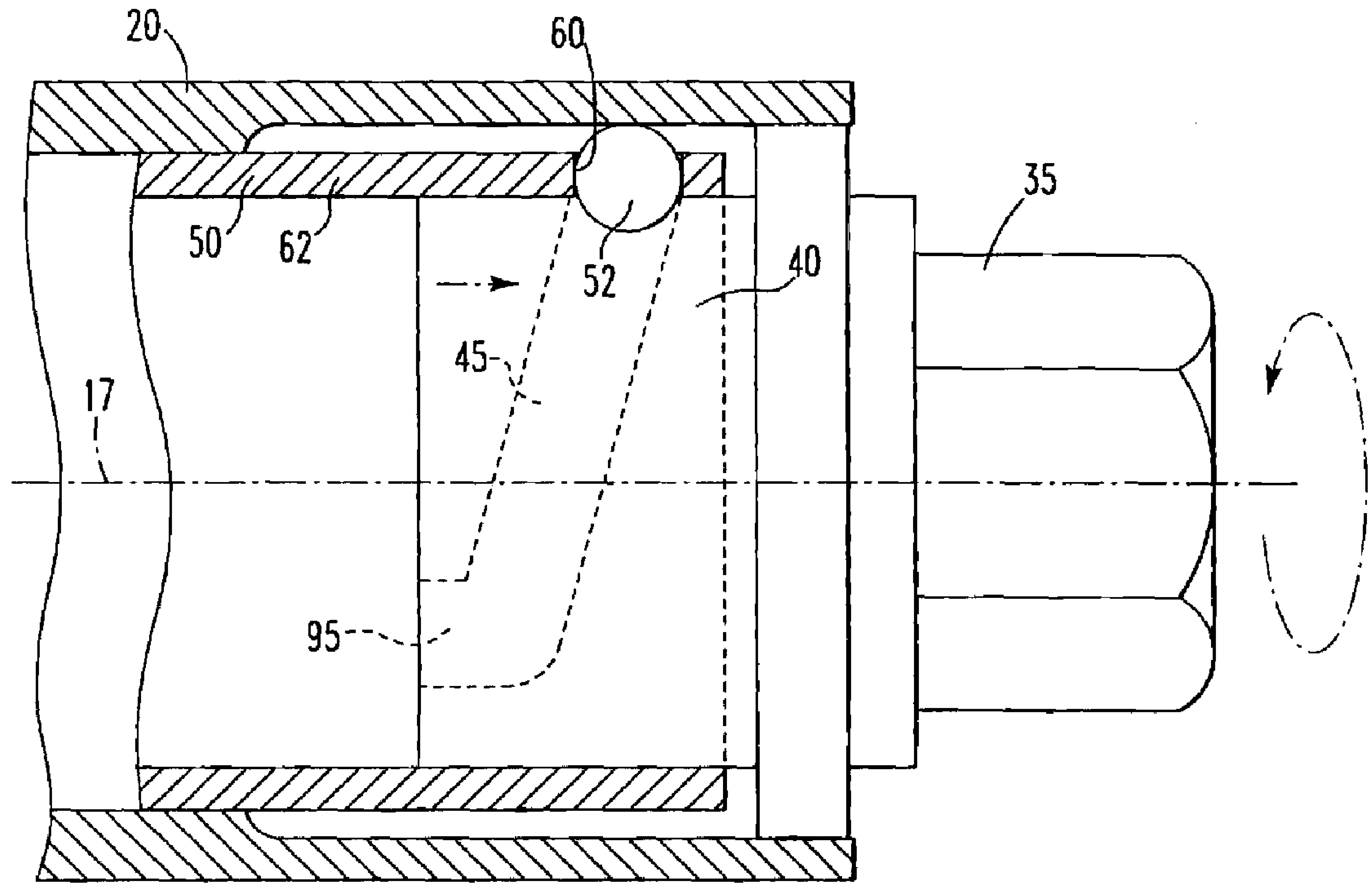


FIG.5

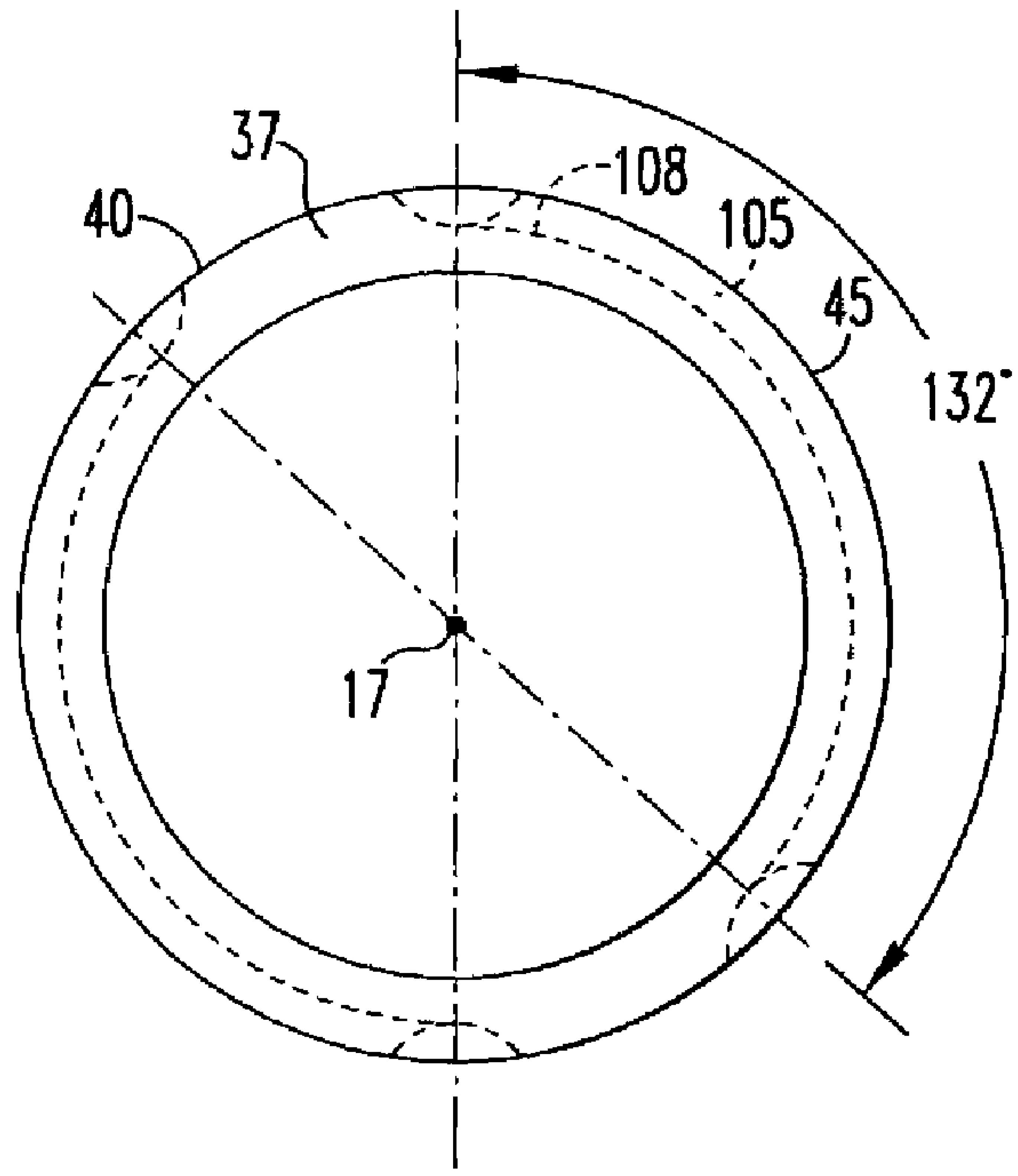


FIG. 4A

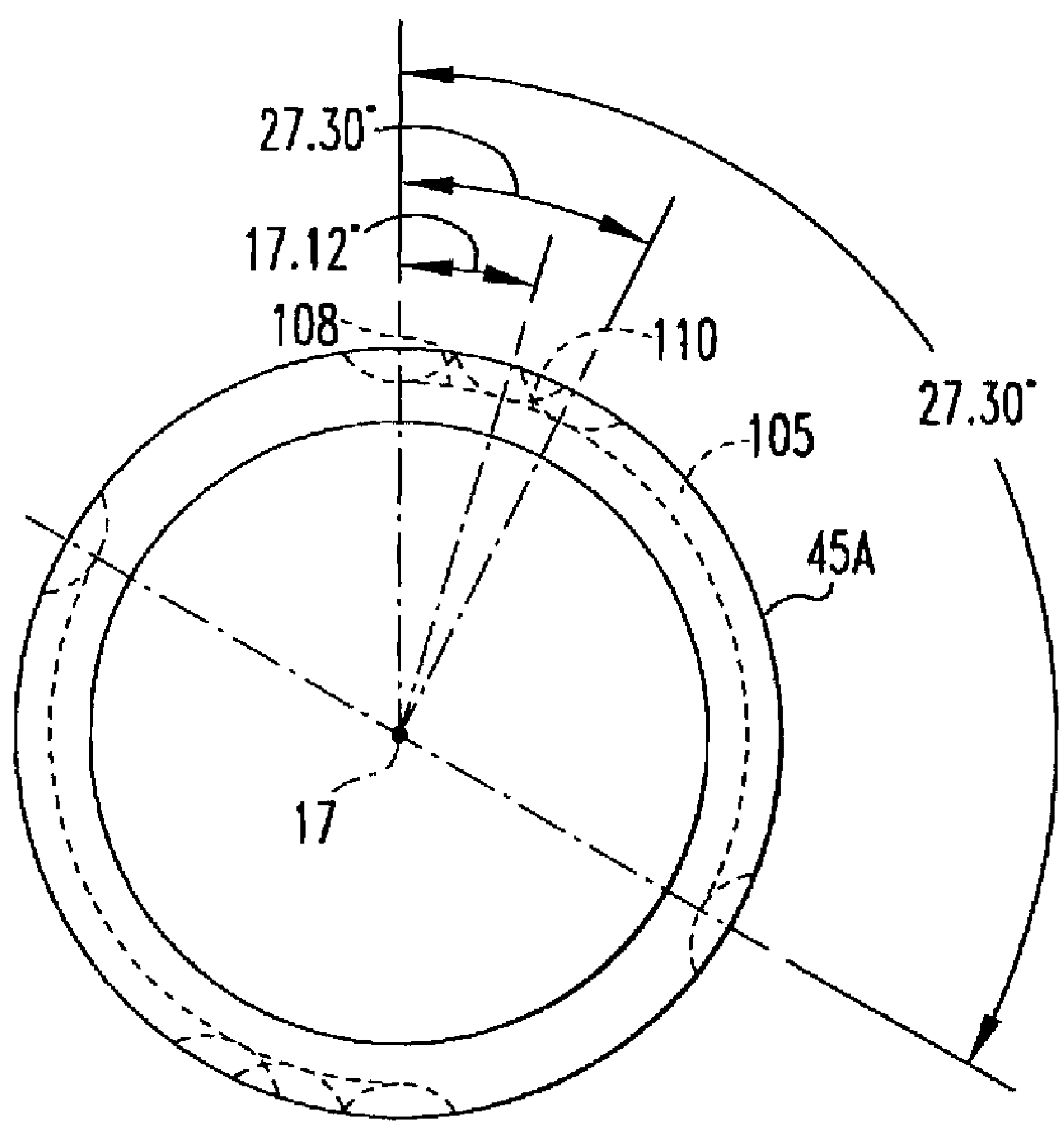


FIG. 8A

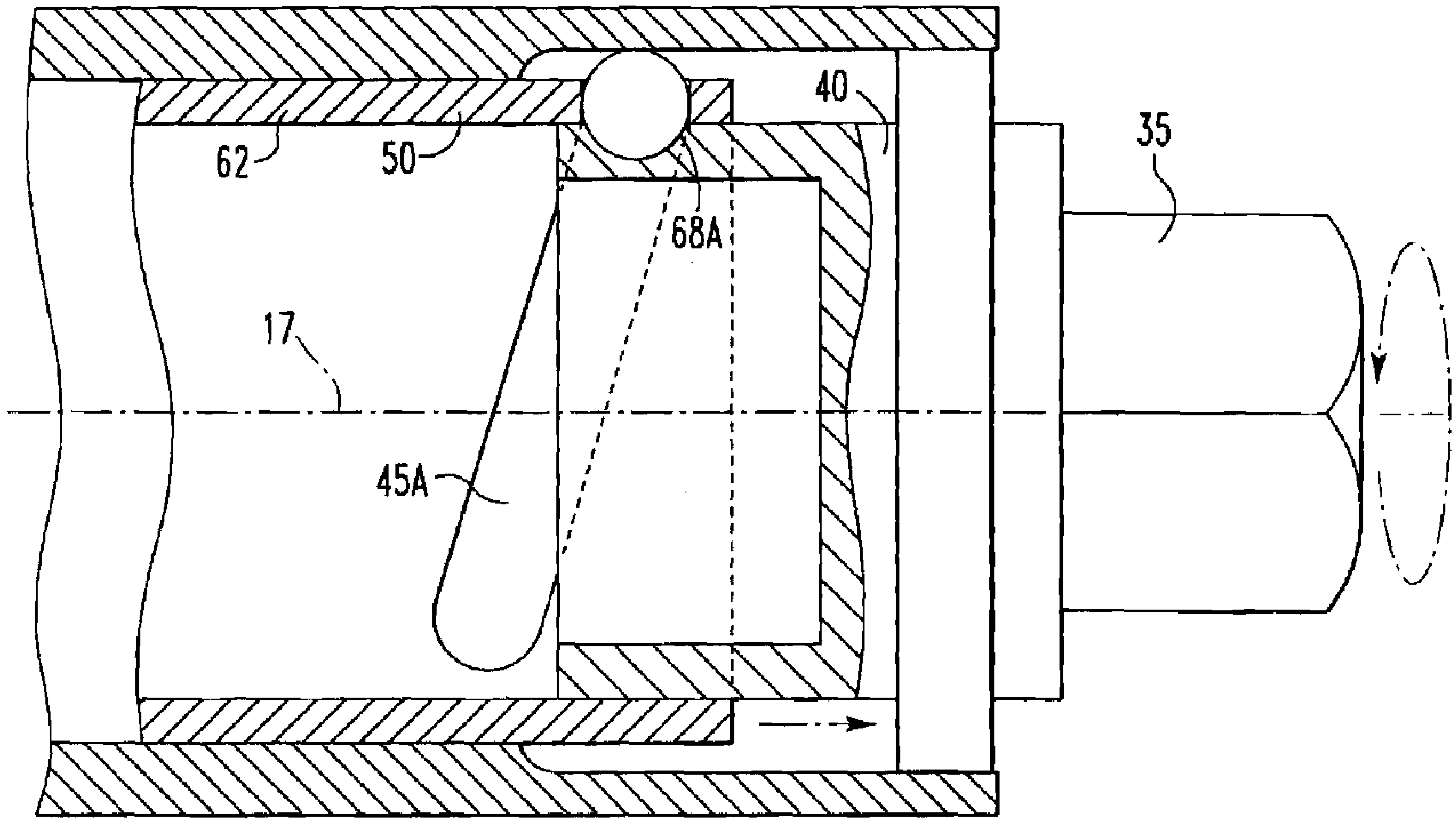


FIG. 6

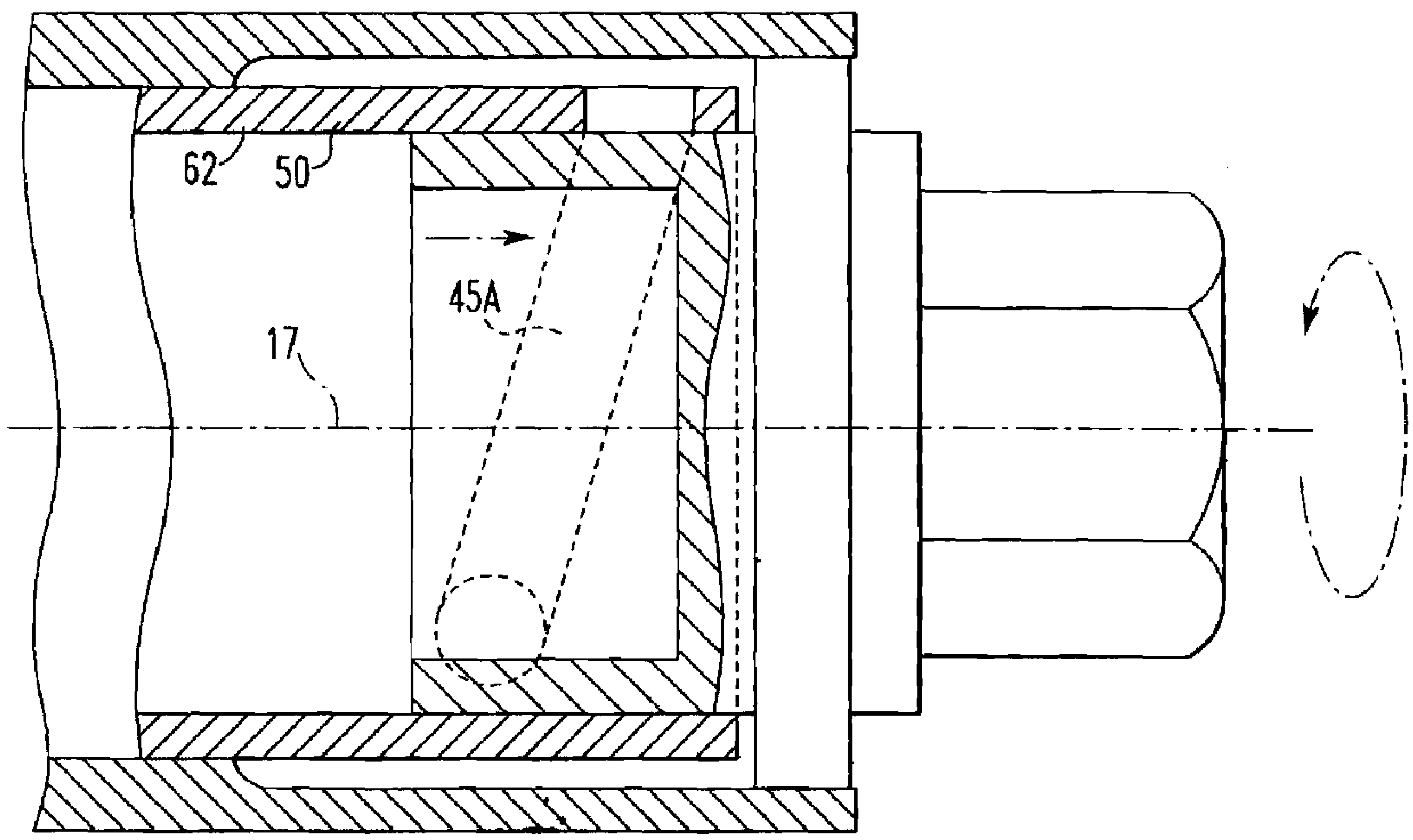


FIG. 7

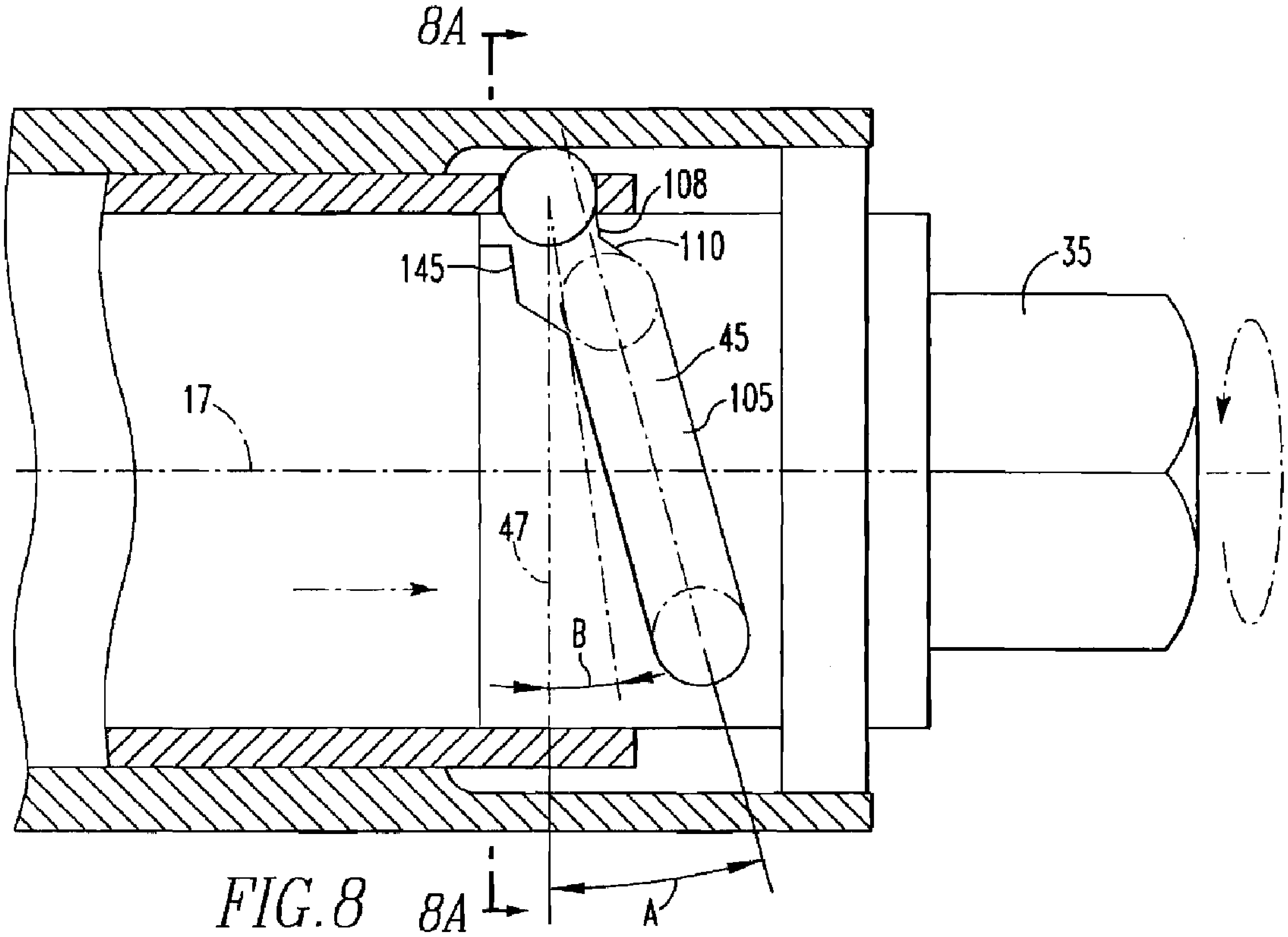


FIG.8

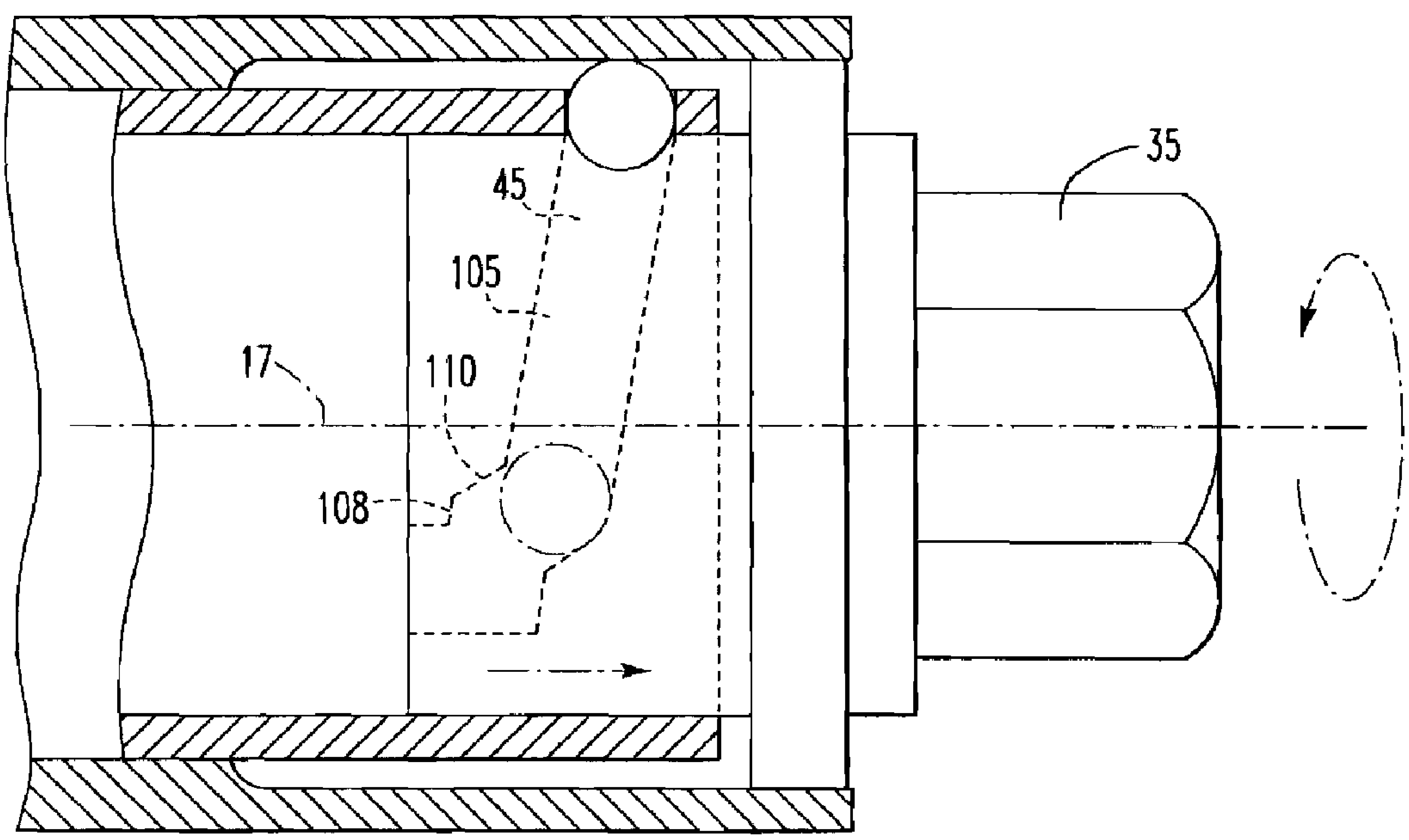
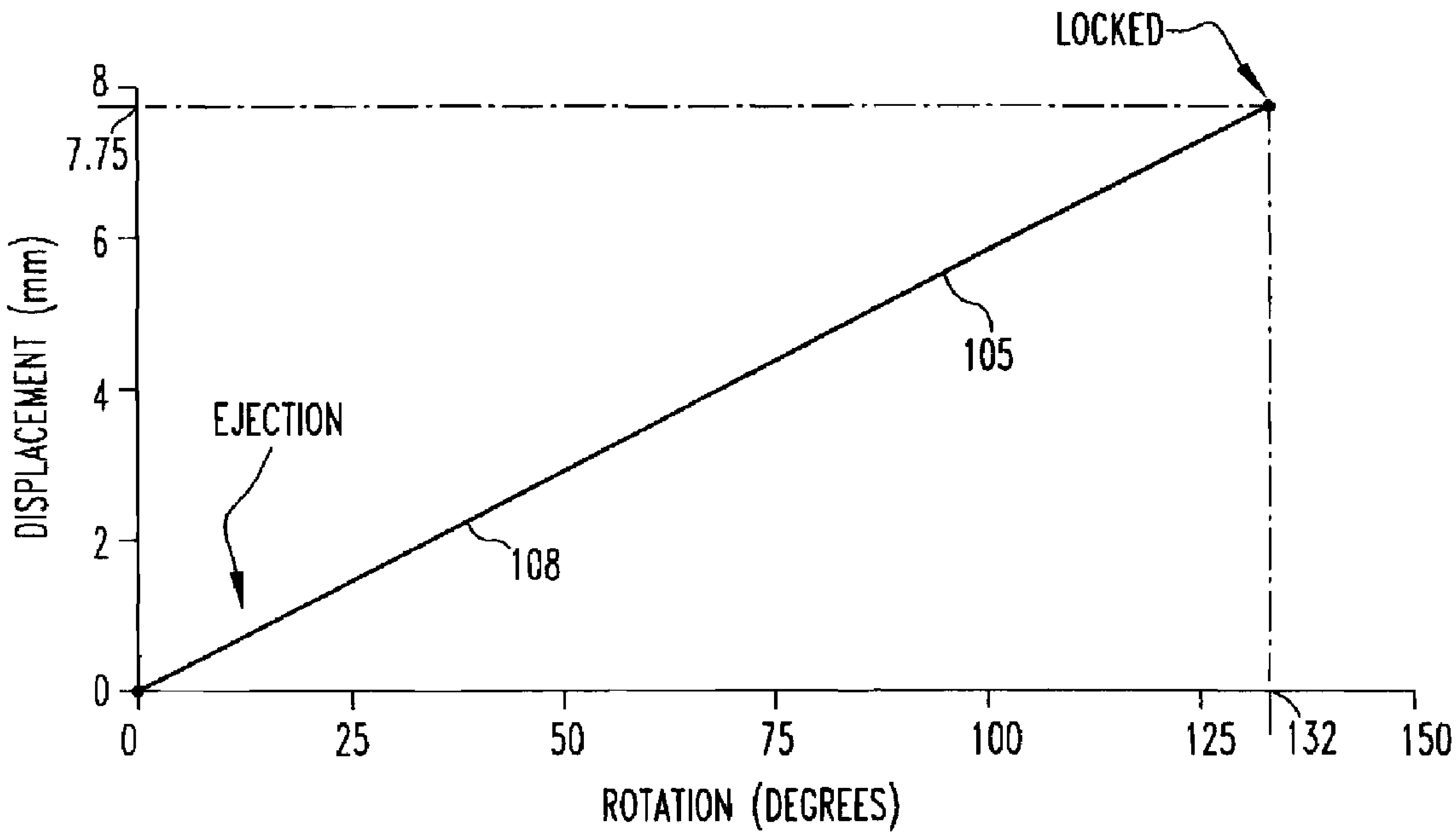


FIG.9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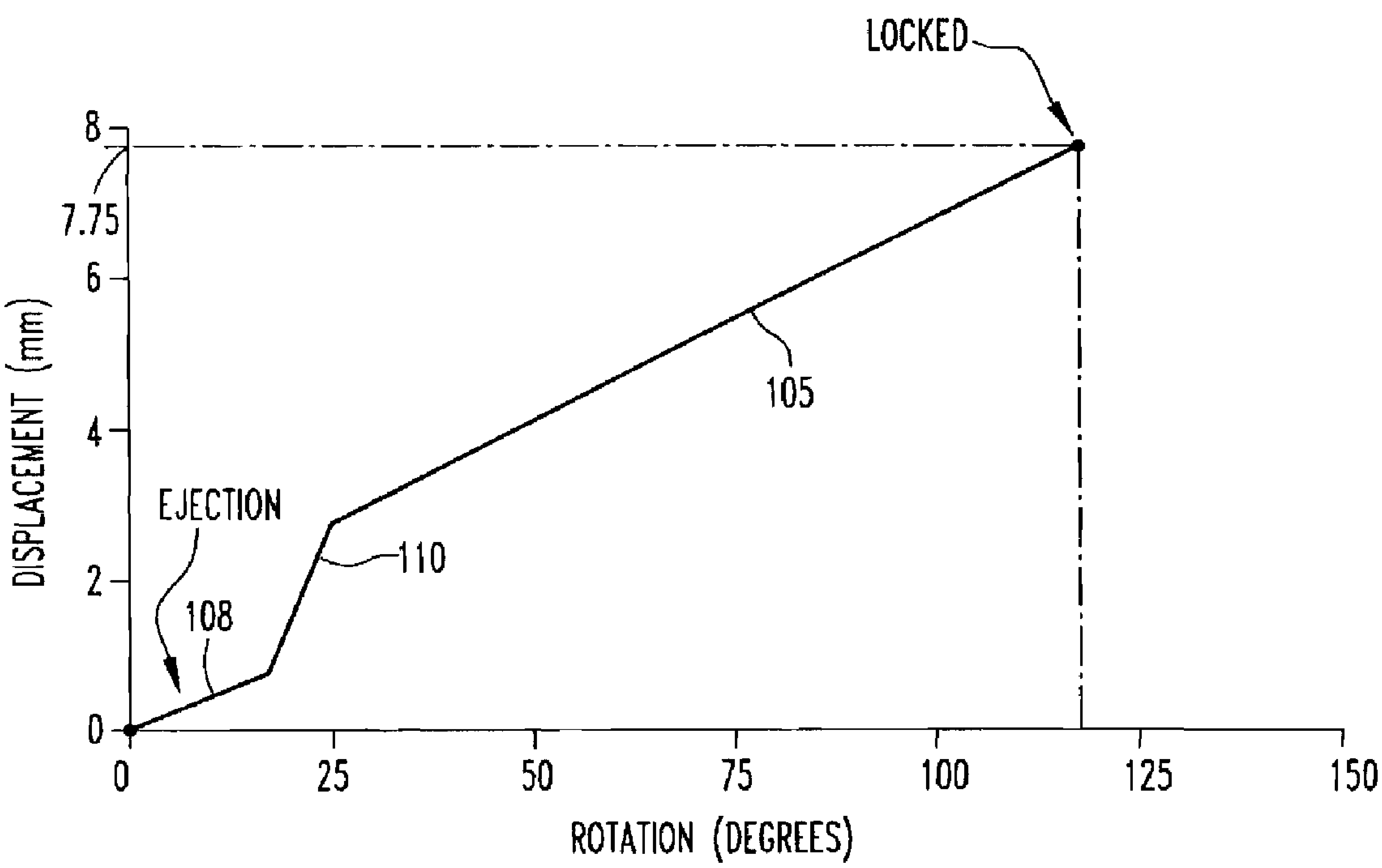
ROTATION (DEGREES)

FIG.10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ROTATION (DEGREES)

FIG.11

TOOLHOLDER ASSEMBLY WITH AXIAL CLAMPING MECHANISM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is directed to tooling for machining operations and, more particularly, directed to a toolholder assembly for precisely locating a toolholder at a selected location within the toolholder assembly during a machining operation.

2. Description of The Related Art

Minimizing the down time of a machine tool in a production environment is critical to the success of a machining facility. Historically, one major contribution to such down time was the time needed to change damaged or worn out cutting tools used by the machine tool. A cutting tool is held by a toolholder, which is typically mounted within a tool support member secured to a machine tool. When the cutting tool must be replaced, the entire toolholder with the cutting tool attached thereto is removed from the support member. A number of couplings are designed to permit quick connecting and disconnecting of the toolholder to and from the tool support member to expedite the tool changing process. One such device is described in U.S. Pat. No. 4,736,659 entitled "Toolholder Assembly for Holding a Toolholder Shank." This patent is co-owned by the Assignee of the present application and is hereby incorporated by reference. The toolholder assembly described in that patent utilizes two locking balls which are urged radially outwardly within a tool support member to engage apertures on the shank of a toolholder. While this arrangement is efficient and permits a toolholder to be removed or secured to a tool support member in a short amount of time, the design of this arrangement may limit its application to tool support members having radial access. Many industrial applications require the use of a tool support member having rear access.

U.S. Pat. No. 5,279,194 entitled "Ball Lock Assembly Without a Canister" is owned by the Assignee of the present application and is hereby incorporated by reference. While this assembly provides for rear access, actuation of the lock rod therein is achieved through multiple rotations of the torque nut and it is difficult to apply a given pull-back force.

In addition to a tool support member having rear access for actuation, a further object of the subject invention is to provide a repeatable maximum pull-back force on the lock rod with a minimum rotation of a rear end torque nut.

SUMMARY OF THE INVENTION

An apparatus for releasably holding a tubular toolholder shank has a base member with a forwardly facing surface and a bore intersecting the forwardly facing surface. The bore extends rearwardly therefrom along a longitudinal axis for receiving the toolholder shank. A lock rod with a forward and rearward end is rotationally restrained about the longitudinal axis and is movable within the base member in a rearward and forward reciprocating motion for pulling the toolholder shank rearwardly within the bore into a locked position and for releasing the toolholder shank from the bore to an unlocked position. A torque nut is rotatively mounted to the base member and operable upon the rearward end of the lock rod to provide the rearward and forward reciprocating motion of the lock rod. The torque nut has a segment with an outer surface and has one of an aperture extending within the outer surface or a groove extending at least partially around the outer surface. At least a portion of the groove is angled relative to the longitudinal axis. A compression sleeve is engaged by the torque nut through at least one compression member and resiliently engages the lock rod. The compression sleeve has the other of an aperture extending within the sleeve or a groove extending at least partially around the sleeve. The aperture is aligned with the associated groove and the at least one compression member is positioned within the groove and within the aperture, such that when the torque nut is rotated in one direction, the at least one compression member and compression sleeve are displaced axially rearward within the base and, when the torque nut is rotated in the opposite direction, the at least one compression member and compression sleeve are displaced axially forward within the base.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as other features and advantages of the invention, will become apparent upon consideration of the detailed descriptions in connection with the several drawings in which:

FIG. **1** is a cross-sectional view of the toolholder assembly in accordance with the subject invention, whereby the lock rod is in the released position and the toolholder is not secured within the base member;

FIG. **2** is a cross-sectional view of the toolholder assembly, whereby the lock rod is in the locked position and the toolholder is secured within the base member;

FIG. **3** is cross-sectional view along lines **3-3** in FIG. **1**, illustrating the manner by which the lock rod is rotationally restrained within the base member;

FIG. **4** is a schematic of the relationship between the torque nut compression ball and compression sleeve illustrating a straight helical groove on the outer surface of the torque nut and its relationship with the compression ball and compression sleeve, wherein the compression sleeve is illustrated in the released position;

FIG. **4**A is a cross-sectional view of the schematic of FIG. **4** viewed along arrows "**4-4**";

FIG. **5** is a sketch similar to that illustrated in FIG. **4**, however, now the torque nut is rotated such that the compression sleeve is in the locked position;

FIG. **6** is a sketch illustrating the groove in the compression sleeve and the compression ball in a aperture in the outer surface of the torque nut, whereby, once again, the compression sleeve is in the released position;

FIG. **7** illustrates a sketch similar to that in FIG. **6**, however, now with the torque nut rotated such that the compression sleeve is in the locked position;

FIG. **8** illustrates a sketch similar to that of FIG. **4**, however, the groove on the outer surface of the torque nut now includes segments of different orientations to assist in releasing the toolholder from the base member, wherein the compression sleeve is illustrated in the released position;

FIG. **8**A is a cross-sectional view of the schematic of FIG. **8** viewed along arrows "**8-8**";

FIG. **9** is a sketch similar to that of FIG. **8**, however, now the torque nut has been rotated such that the compression sleeve is in the locked position;

FIG. **10** is a graph of displacement vs. rotation for the arrangements illustrated in FIGS. **4** and **5** and FIGS. **6** and **7**; and

FIG. **11** is a graph of a displacement vs. rotation representative of the displacement vs. rotation for the arrangement illustrated in FIGS. **8** and **9**.

DESCRIPTION OF THE INVENTION

Directing attention to FIG. **1**, the goal of the toolholder assembly **10** is to move a lock rod **15** back and forth along a longitudinal axis **17** within a base member **20** to secure a toolholder **22** within the base member **20** (FIG. **2**) or to eject the toolholder **22** from the base member **20** (FIG. **1**).

The base member **20** has a forwardly facing surface **27** and a bore **30** intersecting with the forwardly facing surface **27** and extending rearwardly therefrom along the longitudinal axis **17** for receiving the toolholder shank **25** of the toolholder **22**. As illustrated in FIG. **1**, the toolholder shank **25** may freely move in and out of the bore **30**.

The lock rod **15** has a forward end **32** and a rearward end **34**. As will be explained in the discussion of FIG. **3**, the lock rod is rotationally restrained about the longitudinal axis **17**. The lock rod **15** is movable within the base member **20** in a rearward and forward reciprocating motion for pulling the toolholder shank **25** rearwardly within the bore **30** into the locked position, as illustrated in FIG. **2**, and for releasing the toolholder shank **25** from the bore **30** to the unlocked position illustrated in FIG. **1**.

A torque nut **35** is rotatively mounted to the base member **20** and operable upon the rearward end **34** of the lock rod **15** to provide the rearward and forward reciprocating motion of the lock rod **15**. The torque nut **35** has a segment **37** with an outer surface **40**. A groove **45** (FIG. **4**) extends at least partially around the outer surface **40** and, wherein, at least a portion of the groove **45** is angled relative to a line **47** perpendicular to the longitudinal axis **17** to form an angle a. A compression sleeve **50** is engaged by the torque nut through at least one compression member **52**. Additionally, the compression sleeve **50** resiliently engages the lock rod **15** (FIG. **1**). In particular, the lock rod **15** has a pull-back shoulder **54** extending radially outward, while the compression sleeve **50** has a shoulder **56** extending radially inward, and the opposing faces of the lock rod shoulder **54** and compression sleeve shoulder **56** capture and compress a set of springs **58** positioned about the lock rod **15**. The springs **58** may be Belleville washers, as illustrated. The compression sleeve **50** has an aperture **60** extending therethrough to accommodate the compression member **52** which, as illustrated, is a ball. It should be noted that there are two compression members **52**, illustrated in FIG. **1** and FIG. **2**, and each has an associated groove **45**. However, only one compression member **52** and groove **45** set will be discussed, with the understanding that the other set is similar.

When the aperture **60** (FIG. **1** and FIG. **4**) is aligned with the associated groove **45** and the compression member **52** is positioned within both the groove **45** and the aperture **60** (FIG. **1** and FIG. **4**), then, when the torque nut **35** is rotated in one direction, the compression member **52** and the compression sleeve **50** are displaced axially forward within the base member **20**, as illustrated in FIG. **1**, and when the torque nut **35** is rotated in the opposite direction, the compression member **52** and the compression sleeve **50** are displaced axially rearward within the base **20**, as illustrated in FIG. **2** and FIG. **5**.

As illustrated in FIGS. **4** and **5**, the groove **45** is in the outer surface **40** of the torque nut **35** and the aperture **60** extends through the wall **62** of the compression sleeve **50**.

As illustrated in an alternative embodiment, in FIGS. **6** and **7**, it is entirely possible for the aperture **60**A to exist within the outer surface **40** of the torque nut **35**, while the groove **45**A extends within the wall **62** of the compression sleeve **50**.

The purpose of this toolholder assembly **10** is to secure the toolholder **22** within the base member **20**. Although the manner by which the lock rod **15** engages the toolholder **22** is not the focus of the subject invention, this mechanism will be described to assist in understanding the overall operation of the toolholder assembly **10**, with the understanding that this portion of the toolholder assembly may be modified to accommodate other toolholders.

Directing attention to FIG. **1**, the toolholder **22** has a rearwardly facing abutment surface **64** and the toolholder shank **25** is tubular with a shank wall **66** extending rearwardly from the toolholder **22**. Within the shank wall **66** are spaced perforations **68** and within the spaced perforations **68** may be forwardly facing concave contact surfaces **70**.

The toolholder assembly **10** illustrated in FIG. **1** is typical of a toolholder used for non-rotating tooling such as a lathe. However, it should be understood that the toolholder assembly **10** may have attached to it any one of a variety of tools that may be associated with either non-rotating or rotating applications.

As previously mentioned, the base member **20** has a forwardly facing surface **27** and a bore **30**. Within the bore **30**, extending through the base member **20**, is a stub **72** which extends into the bore **30** of the base member **20**. A stub bore **75** extends longitudinally through the stub **72** and the lock rod **15** is slideably mounted within the stub bore **75**.

Toward the forward end **32** of the lock rod **15** are depressions **77** which may be aligned with radial apertures **79** extending through the stub **72** into the stub bore **75**. When the lock rod **15** is moved to the right, locking elements **80** positioned within the apertures **79** of the sub **72** and within the depressions **77** of the lock rod **15** are urged radially outwardly.

FIG. **1** shows the toolholder **22** removed from the base member **20**. To secure the toolholder **22** within the base **20**, the lock rod **15** must be positioned such that the locking elements **80** are within the depressions **77** and recessed within the radial apertures **79**. In this orientation, the locking elements **80** are clear of the perforations **68** within the shank **25** of the toolholder **22** and, therefore, the tubular shank **25** of the toolholder may be inserted into the bore **30**.

As shown in FIG. **2**, with the toolholder **22** positioned within the bore **30**, the lock rod **15** may be pulled to the right, away from the toolholder **22**, such that the locking elements **80** are displaced radially outwardly from the depression **77** onto ramps **82**, thereby causing the locking elements **80** to penetrate the perforations **68** and contact the forwardly facing concave contact surface **70** of the toolholder shank **25**. When the lock rod **15** is retracted to the right, the toolholder **22** is urged within the base member **20** and the rearwardly facing abutment face **64** of the toolholder **22** contacts the forwardly facing abutment surface **27** of the base member **20**. This action of the lock rod **15** secures the toolholder **22** within the base member **20**.

To release the toolholder **22** from the base member **20**, the lock rod **15** is urged to the left toward the toolholder **22**. In such a manner, the locking elements **80** are urged within the radial apertures **79** and depressions **77** so that adequate clearance is provided and the toolholder **22** may be removed from the base member **20** as shown in FIG. **1**.

When the toolholder **22** is locked within the base member **20**, there may exist elastic deformation of the base member **20**, thereby creating high frictional forces retaining the toolholder **22** within the base member **20**. To release the toolholder **22**, the lock rod **15** is extended at the forward end of the base member **20** such that the lock rod **15** protrudes beyond the stub **72** (FIG. **5**) and contacts an impact area **84**, thereby ejecting the toolholder **22** from the base member **20**. Therefore, by moving the lock rod **15**, the toolholder **22** may be secured or released within the base member **20**, thereby providing for quick change of the toolholder **22**.

As mentioned, this mechanism for securing the toolholder **22** within the base member **20** is not part of the subject invention, but is described only to enhance the understanding of the operation of the subject invention. It should be appreciated that the subject invention may be applied to toolholders and lock rods having different geometries than that described herein.

The invention is directed to the mechanism of reciprocating the lock rod **15** by using a predetermined rotation of the torque nut **35** to pull the lock rod **15** back with a repeatable force and, furthermore, to rotate the torque nut **35** in the opposite direction to advance the lock rod **15** to bump off the toolholder **22** from the base member **20**.

Directing attention to FIGS. **1** and **2**, the mechanics for securing the toolholder **22** within the base member **20** will be described. Beginning in the arrangement illustrated in FIG. **1**, whereby the locking elements **80** are recessed within the depressions **77** and the toolholder **22** is free to move in and out of the base member bore **30**, the torque nut **35** is rotated in, for example, a clockwise fashion. The compression members **52** are positioned within the apertures **60** of the compression sleeve **50**. Furthermore, the compression members **52** are captured between the inner wall **90** of the base member **20** and the groove **45** on the outer surface **40** of the torque nut **35**. As illustrated in FIGS. **4** and **5**, the groove **45** has a helical configuration such that, when the torque nut **35** is rotated, the compression member **52** follows the groove and is moved from left to right. Because the compression member **52** is captured within the aperture **60** of the compression sleeve **50**, as the compression member **52** moves from left to right, so does the compression sleeve **50**. The shoulder **56** (FIG. **1**) of the compression sleeve **50** compresses the springs **58** against the shoulder **54** of the lock rod **15**, thereby urging the lock rod **15** from the left to the right, as illustrated in FIG. **2**. As a note, the lock rod shoulder **54** is part of an end cap **92** that may be threadably secured to the end **34** of the lock rod **15**. As the compression sleeve **50** moves further to the right, the springs **58** continue to apply a force to the shoulder **54** of the lock rod **15** and move the lock rod further to the right. The motion of the compression member **52** within the groove **45** is illustrated in FIGS. **4** and **5**, wherein FIG. **4** illustrates the compression member **52** in its forward most position corresponding with the arrangement in FIG. **1**, while FIG. **5** illustrates the compression member **52** in its rearward most position consistent with the arrangement illustrated in FIG. **2**. There is a breakout section **95** illustrated in FIGS. **4** and **5**, and this is a non-functional portion that is intended only for manufacturing to permit an end mill to enter the outer surface **40** of the torque nut **35** and to machine the groove **45**. This breakout section **95** is also illustrated in FIG. **1**.

Redirecting attention to FIG. **4**, at least a portion of the groove **45** is angled with respect to a line **47**, perpendicular to the longitudinal axis **17** and it is this angular orientation coupled with rotation of the torque nut **35** that causes the compression member **52** to move the compression sleeve **50** along the longitudinal axis **17**. As illustrated in FIG. **4**, the groove **45** may be helical with respect to the longitudinal axis **17**. It is of particular note that the entire range of travel for the compression member **52**, from the forward most position illustrated in FIG. **1**, to the rearward most position illustrated in FIG. **2**, is achieved by rotation of the torque nut **35** in an amount less than 180 degrees about the longitudinal axis **17**. In particular, directing attention to FIG. **4A**, which is a sectional view of the torque nut segment **37** along lines **4A-4A** in FIG. **4**, the compression member **52** may be moved between the two ends of the groove **45** with a rotation of the torque nut **35** of 132 degrees. Not only does this provide a predetermined range of rotation of the torque nut **35** to engage or disengage the toolholder **22**, but furthermore, the pull-back force applied to the lock rod **15** is predetermined and is repeatable This occurs because the springs **58** are compressed by the longitudinal travel of the compression sleeve **50**, which itself is limited by the travel of the compression member **52** within the groove **45**.

Directing attention to FIG. **4**, a single groove **45** is used to move the compression member **52** to the left or to the right. The groove **45** illustrated in FIG. **4** forms an angle A with the line **47** perpendicular to the longitudinal axis of between 12 and 22 degrees and preferably forms angle A of approximately 17 degrees. The determination of this angle is based upon the desired compression provided by the compression members **52** upon the lock rod **15** and the desired torque that must be imparted to the torque nut **35** to achieve such a compression. In the arrangement illustrated in FIG. **4**, the same angle A is used to pull back the lock rod **15** and to move the lock rod from right to left, and, as will be discussed, to bump off the toolholder **15** from the base member **20**.

For purposes of discussion, when the compression member **52** follows the groove **45** to move the compression sleeve **50** to the right, the angle A of the groove **45** will define a pull-back pitch. When the compression member **52** follows the groove **45** and moves the compression sleeve **50** from right to left, the angle A will define a bump-off pitch. As will be discussed with respect to the angle of the groove **45**, the force needed to bump off the toolholder **22** from the base member **20** may be greater than the force required to pull back the lock rod **15** to lock the toolholder **22** within the base member **20**.

Directing attention again to FIGS. **1** and **2**, the lock rod **15** has a range of motion along the longitudinal axis **17** including a bump-off region **100** defined by the area where the forward end **32** of the lock rod **15** (FIG. **1**) occupies a portion of the same space as the toolholder **22** would occupy in the locked position (FIG. **2**). As a result, with the toolholder **22** in the locked position within the base member **20**, the lock rod **15** may be advanced to the left (FIG. **1**) to contact the impact area **84** of the toolholder to forcibly push the toolholder **22** from the base member **20**. As illustrated in FIG. **4**, since the groove has a constant angle A, the pull-back pitch of the groove **45** is identical to the bump-off pitch of the groove. The groove **45** extends around the cylindrical outer surface **40** of the torque nut **35** and, as a result, the angle A actually defines a helical angle about the outer surface **40**.

It should be appreciated that the bump-off region **100** (FIG. **1**) is relatively small and, therefore, the motion of the lock rod **15** to eject the toolholder **22** from the base member **20** may also be relatively small. However, depending upon the force of the resilient interference fit with which the toolholder **32** is mounted within the base member **20**, the force required to eject the toolholder **22** may be greater. As a result, while the same groove angle A used for the pull-back section to retain the lock rod **15** within the base member **20** may be used in the opposite direction to eject the toolholder **22**, it may be preferable to change the groove angle A in the bump-off region **100**.

FIGS. **8** and **9** illustrate a groove **45** having a pull-back section **105** and a bump-off section **108** with a transition section **110**, therebetween. As previously discussed, the pull-back section **105** is generally helical and forms and angle A with a line **47** perpendicular to the longitudinal axis **17**. However, for the bump-off section **108**, it is desirable to produce a greater longitudinal force for a given rotation of the torque nut **35** and, as a result, the bump-off section **108** extends along a groove **145** whose center line forms an angle B relative to the line perpendicular to the longitudinal axis **17** of between 5 and 15 degrees and preferably, 10 degrees. By providing a smaller angle, then, for the same torque applied to the torque nut **35**, a greater longitudinal force is generated to eject the toolholder **22** from the base member **20**.

Directing attention to FIG. **2**, it should be appreciated that the torque applied to the torque nut **35** should extend the locking elements **80** radially outward to fully engage the toolholder **22**. On the other hand, to release the toolholder **22**, the torque nut **35** is rotated in the opposite direction and once the locking elements **80** begin to fall within the depressions **77**, the force to move the lock rod **15** to the left is minimal until the forward end **32** of the lock rod **15** encounters the impact area **84** of the toolholder **22**. At that point, the lock rod **15** must apply a greater force to the impact area **84** of the toolholder **22** to bump off the toolholder **22** from the base member **20**. However, between the release of the compression members **52** and the bump-off, the forces that must be applied to the lock rod **15** are minimal. As a result, the transition segment **110** (FIG. **8**) of groove **45** may have a fairly aggressive angle to advance the lock rod **15** a larger distance for a given rotation. Nevertheless, once the compression member **52** advances the lock rod **15** far enough to contact the impact area **84**, then the smaller angle B associated with the bump-off section **108** will permit the application of the same torque to produce a greater longitudinal force to enhance bumping off the toolholder **22**. The bump-off section (**108**) has a bump-off pitch with an angle B relative to a line **47** perpendicular to the longitudinal axis of between 12 and 22 degrees and preferably 17 degrees.

FIGS. **10** and **11** illustrate different displacements of the lock rod **15** for the same rotation of the torque nut **35**. In particular, the constant angle A in FIG. **4** will produce a displacement of the lock rod **15** similar to that illustrated in FIG. **10**. When the torque nut **35** is at the "unlocked" position (FIGS. **1** and **4**), there is no displacement of the lock rod **15** as shown at the "**0-0**" coordinate in FIG. **10**. As the torque nut **35** is rotated, the lock rod **15** is displaced in a linear fashion until the rotation is limited by the groove **45** design. As shown in FIG. **10**, the torque nut **35** rotation is limited to 132 degrees.

However, as previously mentioned, the bump-off region may require forces higher than those needed to lock the toolholder **22** within the base member **20**. The graph in FIG. **11** represents the displacement of the lock rod **15** when the groove **45** illustrated in FIG. **8** is utilized. Moving from the upper right of the graph in FIG. **11**, which represents the "locked" position, as the torque nut **35** is rotated from the locked position, the locking element **80** travels along the pull-back section **105** and enters the transition segment **110** and then the bump-off section **108**. Here the angle of the groove **45** changes such that, for the same torque nut **35** rotation, the lock rod **15** is displaced a smaller amount. This produces a "wedging" effect providing a greater longitudinal force suitable to more easily eject the toolholder **22** from the base member **20**. It should be noted that the composite arrangement of the pull-back section **105**, transition segment **110** and the bump-off section **108**, represented in FIG. **11**, permits the lock rod **15** to travel its entire range with a rotation that is less than the rotation required for the "straight" groove **45**, represented by FIG. **10**.

While discussed herein are helical angles that are constant, it should be appreciated that other non-helical grooves may be utilized to improve the efficiency of the torque nut **35** rotation for different lock rod **15** configurations.

Unlike the pull-back sequence where the shoulder **56** (FIG. **2**) of the compression sleeve **50** engages the springs **58** to act against the shoulder **54** of the lock rod **15**, causing the lock rod **15** to move to the right, during the bump-off sequence, the compression sleeve **50** (FIG. **1**) is moved to the left and encounters the lock rod bump-off shoulder **55** and urges the bump-off shoulder **55** to the left, which in turn urges the lock rod **15** to the left to eject the toolholder. FIG. **2** illustrates the bump-off shoulder **55** with the lock rod **15** in the locked position, while FIG. **1** illustrates the bump-off shoulder **55** contacted by the compression sleeve **50** and urged to the left so that the forward end **32** of the lock rod **15** contacts the impact area **84** and ejects the toolholder **22**.

The lock rod **15** illustrated herein is designed to be held non-rotatable about the longitudinal axis **17**. FIG. **3** illustrates a cross-sectional view of the base member **20** along lines "**3-3**" in FIG. **2**. Of particular note, the lock rod bump-off shoulder **55** is non-circular and fits within a non-circular passageway **112** within the bore **30** of the base member **20**. Through this mechanism, the lock rod is rotationally restrained about but movable along the longitudinal axis **17**.

It should be noted that the toolholder assembly **10** is activated by the torque nut **35** from the rearward end of the base member **20**. Furthermore, the torque nut **35** may have a hexagonal end, such that it may be accessible using commercially available tools. In order to maximize the efficiency of the spring compression, the springs **58** may be pre-loaded between the pull-back shoulder **54** of the lock rod **15** and the shoulder **56** of the compression sleeve **50**.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. The presently preferred embodiments described herein are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

The invention claimed is:

1. An apparatus for releasably holding a tubular toolholder shank, comprising:

a) a base member having a forwardly facing surface and a bore intersecting the forwardly facing surface and, wherein the bore extends rearwardly therefrom along a longitudinal axis for receiving the toolholder shank;

b) a lock rod with a forward and rearward end, wherein the lock rod is rotationally restrained about the longitudinal axis and is movable within the base member in a rearward and forward reciprocating motion for pulling the toolholder shank rearwardly within the bore into a locked position and for releasing the toolholder shank from the bore to an unlocked position;

c) a torque nut rotatively mounted to the base member and operable upon the rearward end of the lock rod to provide the rearward and forward reciprocating motion of the lock rod, wherein the torque nut has a segment with an outer surface and has one of an aperture extending within the outer surface or a groove extending at least partially around the outer surface and, wherein at least a portion of the groove is angled relative to the longitudinal axis;

d) a compression sleeve engaged by the torque nut through at least one compression member and further resiliently engaging the lock rod, wherein the compression sleeve has the other of an aperture extending within the sleeve or a groove extending at least partially around the sleeve;

e) wherein the aperture is aligned with the associated groove and the at least one compression member is positioned within the groove and within the aperture, such that when the torque nut is rotated in one direction, the at least one compression member and compression sleeve are displaced axially rearward within the base and, when the torque nut is rotated in the opposite direction, the at least one compression member and compression sleeve are displaced axially forward within the base.

2. The apparatus according to claim **1**, wherein the groove is in the outer surface of the torque nut and the aperture extends through the wall of the compression sleeve.

3. The apparatus according to claim **1**, wherein the groove is in the wall of the compression sleeve and the aperture is in the outer surface of the torque nut segment.

4. The apparatus according to claim **1**, wherein at least a portion of the groove is angled with respect to the longitudinal axis such that rotation of the torque nut causes the compression member to urge the compression sleeve along the longitudinal axis.

5. The apparatus according to claim **4**, wherein at least a portion of the groove is helical with respect to the longitudinal axis.

6. The apparatus according to claim **4**, wherein the groove extends less than 360 degrees with respect to a radial line extending from the longitudinal axis.

7. The apparatus according to claim **6**, wherein the groove extends approximately 140 degrees, thereby limiting the rotation of the torque nut.

8. The apparatus according to claim **4**, wherein at least a portion of the groove identifies a pull-back section.

9. The apparatus according to claim **8**, wherein the pull-back section extends over the entire groove.

10. The apparatus according to claim **8**, wherein the pull-back section has a pull-back pitch with an angle relative a line perpendicular to the longitudinal axis of between 12-22 degrees.

11. The apparatus according to claim **10**, wherein the pull-back pitch forms an angle of approximately 17 degrees.

12. The apparatus according to claim **8**, wherein the lock rod has a range of motion including a bump-off region defined by the region, wherein the forward position the lock rod occupies a portion of the same space as a toolholder would occupy in the locked position.

13. The apparatus according to claim **12**, wherein the groove in the bump-off region has a bump-off pitch for moving the lock rod forward within the bump-off region.

14. The apparatus according to claim **13**, wherein the bump-off pitch is less than the pull-back pitch.

15. The apparatus according to claim **13**, wherein the bump-off pitch forms an angle with a line perpendicular with the longitudinal axis of between 5 and 15 degrees.

16. The apparatus according to claim **15**, wherein the bump-off pitch angle is approximately 10 degrees.

17. The apparatus according to claim **1**, further including a toolholder within the bore such that the lock rod in the rearward position does not directly contact the toolholder and the lock rod in the forward position directly contacts the toolholder.

18. The apparatus according to claim **1**, wherein the resilient engagement of the lock rod by the compression sleeve is provided by at least one spring.

19. The apparatus according to claim **18**, wherein the at least one spring is captured between a shoulder extending radially outward from the lock rod and a shoulder extending radially inward from the compression sleeve.

20. The apparatus according to claim **18**, wherein the at least one spring associated with the compression sleeve and the lock rod is pre-loaded.

21. The apparatus according to claim **1**, wherein the compression members are balls.

22. The apparatus according to claim **1**, wherein the torque nut is accessible from the rearward end of the base.

23. The apparatus according to claim **22**, wherein the torque nut has a hexagonal end.

24. The apparatus according to claim **1**, wherein the lock rod has a longitudinally extending non-circular section that is slidingly engaged with a longitudinally extending non-circular section of the bore within the base, such that the lock rod may move longitudinally but is rotationally restrained within the base.

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